DO BEA METHODS FULFIL NEEDS OF GLOBAL SUSTAINABILITY INITIATIVES?

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Abstract

The last two decades witnessed the notion of sustainable development making its way into growth of all facets of society, including the building industry, which makes a significant impact on the social, environmental and economic well-being of human beings. At present efforts are being made by the building industry to adhere to sustainability norms by introducing green building practices and building environmental assessment (BEA) methods. Leadership in Energy and Environmental Design (LEED) is a widely accepted BEA method in North America.

The existing BEA methods primarily address environmental issues, which restricts the scope within which the performance of a building could be assessed, and are considered as inadequate in addressing sustainable concerns. This paper attempts to determine the extent to which BEA methods adhere to global sustainability requisites with the aid of Agenda 21 - a blueprint for sustainable development adopted by the UN at the Rio Summit - and three selected BEA methods. Accordingly, global sustainability issues as applicable to building industry are determined by analysis of Agenda 21, and are evaluated against credits from BEA methods to establish additional potential sustainability requirements which are verified through feedback from industry professionals.. This exercise paves way for the development of a system to assess sustainability of buildings.

Key words: Sustainability, Green, Building, Assessment, Agenda 21

1. Background

Sustainable development was the main focus of United Nations Conference on Environment and Development, held in Rio de Janeiro in June 1992 with the participation of over 170 nations, and came to be known as the Rio Summit or Earth Summit of 1992. The Rio Summit adopted the notion of sustainable development as one of its key policy frameworks, thus incorporating environment with social and economic concerns (Chasek, 2001; Seyfang, 2003).

1.1 Agenda 21 and Rio Declaration

Agenda 21 and the Rio Declaration on Environment and Development are two of the key outputs of the 1992 Earth Summit. The Rio Declaration proclaims 27 principles upon which sustainable development policies are to be based, while the structure of Agenda 21comprises of 40 chapters divided under four sections, namely, Social and Economic Dimensions, Conservation and Management of resources for Development, Strengthening the Role of Major Groups, and Means of Implementation. Each chapter proposes several program areas, and sets down goals, basis for action, objectives, activities and means of implementation for each program area (UNDESA, 2009)..

Agenda 21, a comprehensive blueprint of action for sustainable development in the 21st century, is to be taken globally, nationally and locally in every area in which human impacts on the environment. It puts forward the practical interpretation of the concept of sustainable development, attempting to balance the modalities of environmental protection with social and economic concerns (Cleveland and Najam, 2005; Hens and Nath, 2005).

In the global context of sustainable development, sustainability of the construction sector or activities affecting the built environment does not necessarily have to be considered as a separate entity (Gray and Bebbington, 2007). It can be construed as the way in which the construction sector contributes to sustainable development in a much wider scale, rather than confining itself to a particular sector (Atkinson, 2008). Sustainability has inspired major changes in the design profession, and is establishing pre-eminent value systems for itself in architecture and environmental design (Wise, 2001).

In this context, it is worthwhile investigating the contribution made by the building industry and associated professions to the sustainability initiatives.

2. Building Environmental Assessment (BEA) methods

The building industry has been making a significant impact on the natural environment during the last few decades. Operation and maintenance of buildings consume about one fifths of the world's total delivered energy (USEIA, 2010). This corresponds to over 30% of the carbon dioxide emissions that cause global warming and two-fifths of the sulphur dioxide emissions that cause acid rain. It is estimated that buildings worldwide use 40% of virgin

minerals which is associated with landscape destruction, deforestation, air and water pollution.

The response of the building industry to these concerns has been the green building movement, and the last two decades saw the emergence of different building environmental assessment (BEA) methods from different parts of the world, with the aid of which the environmental performance of a building could be assessed. Leadership in Energy and Environmental Design (LEED) in North America and Building Research Establishment Environmental Assessment Method (BREEAM) in UK are two widely used BEA methods. A comprehensive and sophisticated building assessment methods developed through an international effort in recent years has been the Sustainable Building Tool (SB Tool), a system of indicators also known as Green Building Tool (GBTool) .

2.1 Sustainable buildings

The existing BEA methods primarily address environmental issues, and not sustainability concerns, which restricts the scope within which the performance of a building could be assessed (Weerasinghe and Ruwanpura, 2009). According to Chong et al. (2009), while being green concentrates mainly on the environment, being sustainable encompasses a broader continuum of the environment, economy, and society. According to Pope and Morrison-Saunders (2004), BEA methods currently seek to minimize 'unsustainability' and that such systems explicitly seek to minimize environmental impacts, but often fail adequately to take into account social and economic indicators. Cole et al. (2005) emphasize on the need for recasting environmental assessment methods under the umbrella of environmental, social and economic sustainability. Fenner and Ryce (2008) agree that future assessment tools should be developed adequately to address sustainability as a whole rather than focus on environmental indicators.

3. Research objectives

The forgone discussion highlights the need to broaden the capacity to BEA methods /tools to encompass the main spheres of sustainability – environmental, social and economic – as the next stage of development. Accordingly, this paper attempts to determine the extent to which global sustainability initiatives are addressed by current BEA methods, while proposing possible additional objectives that could be incorporated with future BEA methods.

3.1 Scope and limitations

Three current BEA methods were analyzed for the study, namely, LEED NC Canada (2009), BREEAM Offices 2008, and SB Tool. The main focus of the research was on Office Buildings.

Agenda 21 was taken as the basis upon which the selected BEA methods were analyzed to determine the extent to which these methods address sustainability issues. Further, the main

focus of the research was on the pre-project planning and design phase of the project life cycle.

4 Methodology and analysis

4.1 Methodology

Being a descriptive research, the scope of research was limited to content analysis. The methodological steps were as follows.

1. Comprehensive evaluation of the three BEA methods. All credits were examined and grouped under several categories, according the objectives and requirements for each credit.
2. Examination of Agenda 21 to identify goals /objectives /activities applicable to buildings, and relevant clauses were scrutinized and listed under the categories identified in step 2.
3. Based on the credits from BEA methods, and intents of Agenda 21, possible sustainability objectives awee determined for each category. For each objective, the relevant credits from BEA methods were identified, thus verifying the extent to which BEA methods address sustainability objectives.
4. For each category, if sustainability requirements were not met by the objectives determined under step 4, additional objectives were introduced.
5. The objectives were finalized in two stages. Initially, the objectives formulated, over 150 in number, were taken up for discussion by a focus group made up of building industry professionals, and were reduced to 64 objectives. During the second stage, a series of interviews were conducted with LEED Accredited professionals, following which the number of objectives were finalized as 72. The final set of objectives are taken up for analysis in this paper, while details of the focus group session and interviews are not described in detail due to limitation in the scope of this paper. .

From each category, it is possible to determine the total number of sustainability objectives derived, and the compatible credits from each BEA method. The numbers from all categories can be totaled so as to verify the extent to which the selected BEA methods fulfill sustainability requirements. Two categories which emphasize on environmental sustainability, and have a comparatively high number of compatible BEA credits are taken up to detailed discussion.

4.2 Analysis

A total of 72 objectives under the following 10 categories were identified, and two categories, namely, D and E, are taken up for discussion in the following sub-chapter.

Category A: Process Management - Management and decision making during the pre-project planning and design process.

Category B: Context, Community and Connectivity - Underlines response of the building to the context including socio-cultural and economic aspirations of the community.

Category C: Site, Site Development and Ecology - Efficient utilization of land resources and effective site utilization minimizing impacts on the site and surroundings.

Category D: Materials, Processes and Products -Minimization and efficient utilization of materials, use of environment friendly materials and manufacturing processes including recycled material.

Category E: Energy - Attempts to minimize energy consumption and corresponding atmospheric emissions.

Category F: Health and Comfort - Attempts to ensure health, safety and well-being for the occupants of the built environments.

Category G: Spatial Attributes - Focuses on internal space arrangement and configuration.

Category H: Waste - Category H encourages sustainable waste management, collection and recycling during construction and operation of the building.

Category J: Water - Minimization of water consumption and wastewater management.

Category K: Facility Management - Only the decisions pertaining to the management of the facility not proposed under the above categories are suggested. This does not take into account decisions taken during O&M of the facility, which involves a separate set of objectives.

The following two categories are discussed in detail, and with the objectivess, corresponding Agenda 21 clauses and the compatible BEA credits (from LEED, BREEAM and SBTool) presented in tabulated form. The descriptions of Agenda 21 chapters and BEA credits for each objective are found within the text of the subchapters, along with short discussions.

4.2.1 Category D: Materials, Processes and Products

Minimization and efficient utilization of materials, use of environment friendly materials and manufacturing processes, including recycled materials are considered under category D (Table 1).

The relevant Agenda 21 chapters are - Chapters 4.2: Develop criteria and methodologies for the assessment of environmental impacts and resource requirements throughout the full life cycle; 6.41: Develop appropriate pollution control technologies; 7.69: Promote the use of construction and maintenance technologies which generate employment in the construction sector for the underemployed labour force; 7.7: Discourage the use of construction materials and products that create pollution during their life cycle; 9.17: Promote efficient use of materials and resources, taking into account the life cycles of products, in order to realize the

economic and environmental benefits of using resources more efficiently; 11.21: Maximize the use of waste and improve value of both wood and non-wood forest products; 16.22: Production processes making optimal use of natural resources, by recycling biomass; 16.23: Develop processes that make use of biodegradable materials; 21.24: Encouraging the use of recyclable materials.

Table 1 - Category D: Materials, Processes and Products

No	Objectives *(Corresponding Agenda 21 chapters)*	BEA Compatible credits		
		Leed	**Breeam**	**SBTool**
D1	Conservation /Reuse and management of existing structures *(Chapters 7.7, 9.17, 16.22, 16.23)*	MRc1.1 MRc1.2	Mat3 Mat4	B4.1
D2	Reuse of materials and products *(Chapters 7.7, 9.17, 16.22, 16.23)*	MRc3	-	B4.5
D3	Life cycle assessment *(Chapters 4.2, 7.69, 7.70, 9.17)*	-	Mat1,Mat2, Mat6	B1.1 C1.1
D4	Ensuring durability of buildings *(Chapters 4.2, 7.69, 7.70, 9.17)*	RP1	Mat7	B4.4
D5	Recycled content *(Chapters 11.21, 16.23, 21.24)*	MRc4	Wst2	B4.6,B4.8
D6	Renewable materials *(Chapters 11.21, 16.23, 21.24)*	MRc6	-	B4.7
D7	Responsible sourcing of materials. *(Chapters 7.69, 16.23)*	MRc7	Mat5	-
D8	Regional materials (Chapter 7.69)	MRc5	-	B4.9
D9	Non-polluting materials. *(Chapters 6.41, 7.7)*	IEQc1	HAE9	D1.3

The requirements for Category C are met by the three BEA methods and there is no need to introduce new objectives. However, Life Cycle Assessment, although taken into account under D3, is not considered for any of the other compatible credits in the BEA methods. LCA is given priority in this Category, and it should be considered as a requirement for D5, D6, D7, D8 and D9 when determining criteria for the objectives. The compatible credits are as follows:

Objective D1

LEED: MRc1.1 and MRc1.2 - Reuse of existing building: structure, shell and non-shell elements and upgrade components; **BREEAM:** Mat3 and Mat4 - Re use of façade and structure; **SBTool** - Re use of suitable existing structures.

B4.1 credit is based on the area of existing structure that can be re-used as part of the project, thereby confining reuse only to structural elements. The two BREEAM credits are confined to reuse of facade and structure only. The two LEED credits fulfill the requirements for this objective.

Objective D2

LEED: MRc3 - Reuse bldg materials and products. Identify opportunities to incorporate salvaged materials into building design; **SBTool**: B4.5 - Reuse of salvaged materials.

Both LEED and SBTool allocate points based on the cost of reused materials, with SBTool specifying a higher threshold limit. Therefore, criteria for B4.5 can be considered as the requirement foe this objective.

Objective D3

BREEAM: Mat1- Materials specification. Encourage use of materials with low environmental impact over life cycle of building, Mat2 - Hard Landscaping and Boundary Protection. Materials to have low env impact, taking into account full life cycle of the materials , Mat6 - Insulation: To have low embodied environmental impact and be responsibly sourced; **SBTool**: B1.1 - CO2 emissions from primary non renewable energy used in the manufacture and transportation of materials and components, C1.1 - minimize amount of annualized GHG emissions embodied in construction materials.

According to BREEAM requirements, BRE's Greenguide (a reference website and electronic tool, copyright of BRE Global Ltd.) is be used to evaluate the environmental impact of building components over life cycle of a building, but the calculator is available only for licensed BREEAM assessors. The scope credits in SB Tool are confined to predicting embodied energy of materials, and, annualised GHG emissions embodied in materials. As such, it is necessary to develop an LCA tool according to the location / region to fulfil the requirements for this objective.

Objective D4

LEED: RP1 - Minimize material use and construction waste over life of a building. Design strategies to minimize premature deterioration of components; **BREEAM** - Mat7 - Adequate protection of exposed parts of bldg; **SBTool** - B4.4 - Use of durable materials. To meet or exceed service life of the building.

Mat7 recognizes protection to areas mainly subjected to pedestrian and vehicular traffic. The requirements as set out for RP1 of LEED is comprehensive and meets with the requirements for this objective.

Objective D5

LEED: MRc4 - Establish project goals for recycled content materials, thus reducing impacts from extraction and processing, by passing energy and GHG intensive manufacturing processes; **BREEAM:** Wst2 - Recycled aggregates. Relevant specifications or contract clause; **SBTool :** B4.6 - Use of recycled materials from off site sources. To be incorporated with contract documents, B4.8 - Use of cement supplementing materials in concrete. Fly ash, steel slag or rice ash, to reduce GHG emissions from use of cement.

Wst2 is one component of recycled content, while requirements of B4.8 are incorporated with those of MRc4. The criteria for D5 can be based on the LEED requirements, with more stringent threshold levels and with justification by a LCA.

Objective D6

LEED: MRc6 - Establish project goals to reduce use and depletion of finite raw materials and long cycle renewable materials by replacing them with rapidly renewable materials; **SBTool**: B4.7 - Use of bio-based products obtained from sustainable sources. Certified as coming from renewable sources or equivalent.

While B4.7 is confined for use of bio-based products, it requires certification for responsible sourcing. Therefore, the criteria from both LEED and SBTool credits, when amalgamated meets with the requirements for D6, but still require justification by LCA.

Objective D7

LEED: MRc7 - Certified wood. Encourage environment friendly forest management by establishing a project goal for FSC certified wood; **BREEAM**: Mat5 - Responsible Sourcing of Materials. Encourage the specification of responsibly sourced materials for key bldg elements.

Both BEA methods fulfill the requirements for D7, but require LCA as a means of justification.

Objective D8

LEED: MRc5 - Regional materials. Regionally sourced (extracted and manufactured) materials and products; **SBTool** : B4.9 - Use of materials that are locally produced. Encourage procurement of high weight materials – aggregates, sand, concrete, masonry, steel & glass from sources within the greater urban region.

SB Tool requires only high weight materials to be locally produced, whereas LEED takes into account all materials without making any such distinction. However, LEED specifies a maximum distances between the construction site, final manufacturing site and points of extraction, harvesting, recovery and processing, while SB Tool states that the distances could vary for different areas, and specifies that the point of manufacture be within the greater urban area. Therefore, requirements of D8 can be fulfilled if criteria of both BEA methods are amalgamated, and justified through LCA.

Objective D9

LEED: IEQc1 - Low emitting materials. Reduce amount of indoor air contaminants harmful to installers and occupants by specifying low VOC materials; **BREEAM**: Hea9 - Volatile Organic Compounds. Specify low emission VOC materials for a healthy indoor environment; **SBTool**: D1.3 - Off-gassing of pollutants from interior finish material. Interior finishing materials with zero or minimal rates of VOCs

Both LEED and BREEAM require low VOC contents as criteria, whereas, D1.3 requires zero VOC emissions from all indoor materials. As such, SB Tool criterion fulfills the requirements for D9.

4.2.2 Category E: ENERGY

Category E attempts to minimize energy consumption and corresponding atmospheric emissions. A new objective that encourages generation of surplus energy is introduced (Table 2).

The relevant Agenda 21 chapters are - Chapters 4.18: Environmentally. sound use of new and renewable sources of energy; 7.49: Provision of alternative/renewable energy for human settlements; 7.51: Promote integrated development of energy-saving and renewable energy technologies, particularly for the use of solar, hydro, wind and biomass sources; 7.69: Use of energy-efficient designs and technologies and sustainable utilization of natural resources; 9.12: Use of improved energy-efficient technologies and practices and polluting forms of energy; 9.20: Reduction of atmospheric pollution and/or the limitation of anthropogenic emissions of greenhouse gases: 9.23: Use of alternatives to substances that deplete the ozone layer: 9.24: Making available substitutes for CFCs and other ozone-depleting substances; 12.1: Use of other sources of energy, including alternative sources of energy.

Table 2 - Category E: Energy

No	**Objectives *(Corresponding Agenda 21 chapters)***	**BEA Compatibility**		
		Leed	**Breeam**	**SBTool**
E1	Minimize energy consumption *(Chapters 4.18, 7.49, 7.51, 9.12,12.1)*	EAp2, EAc1	Ene1,Ene4 Ene8,Ene9	B1.2, B2,C1.2
E2	Use of renewable energy *(Chapters 7.49, 7.51, 7.69, 9.12, 9.20)*	EAc2,EAc6 SS4.3	Ene5	A2.1,A2.9 B3.1,B3.2
E3	Generation of surplus renewable energy within the building (*Chapters 7.49, 7.51, 7.69, 9.12)*	-	-	-
E4	Minimizing electrical peak demand *(Chapters 4.18, 7.49, 7.51, 9.12,12.1)*	-	-	B2
E5	Reduction of ozone depleting emissions from energy use. *(Chapters 9.23, 9.24)*	EAp3, EAc4	Pol1,Pol2	C2.1
E6	Minimizing / Elimination of acidifying emissions. *(Chapter 9.20)*	-	Pol4	C2.2

A new objective (E3) is introduced, thus encouraging the generation of energy within the premises where surplus energy could be a source of income generation. For objective E1, achievement of zero carbon technologies is considered as the ultimatum, a requirement set down only in BREEAM. The compatible credits are as follows:

Objective E1

LEED: EAp2 - Design bldg. envelope and system to maximize energy performance, EAc1 - Achieve increasing levels of energy performance above prerequisite standards; **BREEAM**: Ene1 - Reduction of CO2 emissions. Operational energy consumption. Ene4 - To encourage the specification of energy-efficient light fittings for external areas of the development, Ene8 & Ene9 - Lifts, escalators and travelling walkways. To recognise and encourage the specification of energy-efficient transportation systems; **SBTool**: B1.2 - To minimize amount of non renewable energy for facility operations, B2 - Minimize electrical peak demand for facility operations, C1.2 - Minimize annual GHG emissions from all energy used for facility operations.

BREEAM's Ene1 equates energy consumption with CO_2 emissions by specifying values based on CO_2 index, whereas, SB Tool and LEED credits take into account overall energy use in the building. All three BEA methods fulfill the requirements for E1, but with varying threshold levels.

Objective E2

LEED: EAc2 - Renewable energy. On-site energy self-supply, maximum 13%, to reduce fossil fuel energy use, EAc6 - Green power. Provide at least 35% of electricity from renewable sources, SSc4.3 - Alternative Transportation: Hybrid and alternative fuel vehicles; **BREEAM**: Ene5 - Low or zero carbon technologies. Encouraging local energy generation from renewable sources; **SBTool**: A2.1 - Feasibility of use of renewables, A2.9 - Building orientation to maximize passive solar potentia, B3.1 - Use of off-site energy that is generated from renewable sources, B3.2 - Provision of on-site renewable energy systems.

Ene5 allocates points for use of both on-site and off-site energy, without distinguishing between the two types, whereas both LEED and SB Tool address on-site and off-site energy through separate credits. SB Tool's A2.9 on site orientation is one of the passive means of maximizing solar energy potential, and is only one of the several techniques of utilizing renewable energy. Therefore, BREEAM fulfills the requirements for E2.

Objective E4

SBTool: B2 - Minimize electrical peak demand for facility operations.

SB Tool is the only BEA method specifying electrical peak demand, and accomplish the requirements for E4

Objective E5

LEED: EAp3 - CFC reduction in HVAC & R equipment, EAc4 - Selection of refrigerants and HVAC&R so as to minimize or eliminate ozone depletion and global warming. **BREEAM**: Pol1 - Reduce refs with high global warming potential. Pol2 - Reduce emission of refs due to leaks in cooling plants; **SBTool**: C2.1 - Minimize emissions of ozone depleting substances during facility operations.

The requirements of LEED pre-requisite which requires zero use of CFC based refrigerants, and the LEED credit, EAc4 which takes into consideration ozone depletion potential, global warming potential and refrigerant leakage rate fulfill the requirements for E5.

Objective E6

BREEAM: Pol4 - Minimizing NOx emission; SBTool: C2.2 - Minimizing of acidifying emissions during facility operation.

Requirements from both Pol4 and C2.2, both of which when taken together attempt to minimize of NO_x and SO_2 or equivalent emissions from facility operation, fulfill the requirements of E6.

4.3 Summary

The extent to which BEA methods address sustainability issues, as depicted in the 10 categories, is summarized and shown in Table 3.

Table 3. Fulfillment of sustainability requirements by BEAs for each category

Category	**No. of objectives**	**Accomplishment of each BEA**		
		LEED	**BREEAM**	**SB Tool**
A. Process Management	09	03 (33%)	02 (22%)	04 (44%)
B:Context,Community and Connectivity	11	05 (45%)	03 (27%)	09 (82%)
C: Site, Site Development and Ecology	07	07 (100%)	06 (86%)	07 (100%)
D: Materials, Processes and Products	09	08 (89%)	06 (87%)	08 (89%)
E: Energy	06	03 (50%)	04 (67%)	05 (83%)
F: Health And Comfort	09	05 (56%)	06 (67%)	07 (78%)
G: Spatial Attributes	07	00 (0%)	01 (14%)	03 (33%)
H: Waste	04	03 (75%)	02 (50%)	03 (75%)
J: Water	04	02 (50%)	01 (25%)	02 (50%)
K: Facility Management	06	01 (17%)	02 (33%)	04 (67%)
Total	**72**	**37 (51%)**	**33 (46%)**	**52 (72%)**

Overall, LEED and BREEAM credits are compatible with requirements for only about 50% of the sustainability objectives, whereas SB Tool credits address 72% of the objectives. This analysis illustrates that while SB Tool responds to sustainability needs to a certain extent; both LEED and BREEAM need considerable enhancement in order to be considered for measurement of sustainability.

Both LEED and BREEAM rating systems fail to accomplish even 50% of the sustainability requirements for four categories, which are, A: Process management, B: Context, Community and Connectivity, G: Spatial Attributes and K: Facility Management.

The detail discussion is confined to two categories which deal mainly with environmental issues and have a large number of compatible credits from all three BEA methods. However, even the most compatible BEA credits, taken individually, fail to fulfill the requirements of the respective objectives. they have to be combined together to alleviate the shortcomings of each credit. It is thus possible to establish the notion that amalgamation of several BEA methods could yield a more comprehensive tool for building performance assessment.

5 Conclusion

BEA methods, despite being recent introductions into the construction industry, are beginning to make their impact felt in the design and construction of built environments. LEED is getting wide recognition, not only in North America where it originated, but in other parts of the world as well. Majority of stakeholders are looking up to BEA methods as the solution to the predicament the industry finds itself in with regard to environmental, economic and social issues involved. Therefore, it becomes imperative for the BEA methods to address the wider spectrum of sustainability rather than merely environmental concerns.

This paper had highlighted the deficiencies found in BEA methods in dealing with purely environmental as well as sustainability issues, and has come up with a possible solution by evaluating BEA methods against a globally accepted sustainability initiative and proposing additional objectives that can be incorporated in the formulation of assessment methods in the future.

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